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Use of Swarm data to study the core surface magnetic field

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ESA's Swarm satellite trio, designed to deliver the best ever survey of the Earth's magnetic field was launched on 23rd November 2013. As planned, two satellites are now flying close together (150 km apart) at a relatively low altitude (approx. 460 km) while a third satellite is flying at a higher altitude (approx. 520 km) and drifting at a different rate in local time. All three are equipped with high precision vector and scalar magnetometers, with three star cameras on each satellite providing the necessary attitude information. Here, we present initial results showing how the first 6 months of data from the vector field magnetometers can be used to study the core surface magnetic field and its time changes. The orbital configuration of the constellation is still evolving, with all the satellites slowly descending and the higher satellite drifting to a different local time, as required for improved separation of the internal and external fields. Efforts to improve the calibration of the magnetic field data are also ongoing. Overall, we can now look forward to a long (approx. 10 year) mission that has already begun to provide high quality, multi-point, measurements of the geomagnetic field.

We report results obtained via an update of the CHAOS series of field models (Olsen et al, 2006, 2009, 2010, 2014) to include the first 6 months of Swarm vector field magnetometer data, along with recent ground observatory monthly means. Quiet-time, night-side, data selection criteria have been used, and the magnetic field data is used in the instrument frame with Euler angles for the rotation to the North-East-Center (NEC) frame co-estimated in 10 day bins. We have determined a time-dependent model of the internal field spanning more than 15 years between 1999 and 2014.5, up to spherical harmonic degree 20, using a 6th order spline representation with knot points spaced at 0.5 year intervals. We applied regularization penalizing the third time derivative of the field at the core surface during the model span, and also the second time derivative at the model endpoints. The new field model now consistently fits data from 6 different satellites: Ørsted, CHAMP, SAC-C and the three Swarm satellites. The rms misfit to the Swarm data in the NEC frame is lower than that to data from previous satellite missions. We also find that the new model provides a good description of observatory secular variation, capturing rapid field evolution events during the past decade. Maps of the core surface field and its secular variation in the Swarm-era, the time changes in the model secular variation for specific coefficients, and the evolution of the model secular acceleration are presented. From these initial investigations, we conclude that Swarm data is suitable for building high-resolution models of the time-dependent core field. Further work is now needed to take explicit advantage of Swarm data. This will involve using a longer time span of data, better inter-calibration of scalar and vector magnetometer data, and using the constellation aspects of Swarm via gradient measurements. The preliminary field model presented here, CHAOS-4plus_V3 is available for download from the webpage: http://www.spacecenter.dk/files/magnetic-models/CHAOS-4/.